Review of

White Paper: Salmonid Travel Time and Survival Related to Flow in the Columbia River Basin

Northwest Fisheries Science Center
National Marine Fisheries Service
March, 2000

Submitted by the Idaho Department of Water Resources
Karl J. Dreher, P.E., Director
1301 North Orchard Street
Boise, Idaho 83712

October 30, 2000

A.) Introduction

The purpose of this document is to provide comments on the NMFS White Paper entitled "Salmonid Travel Time and Survival Related to Flow in the Columbia River System." The comments address (1) the White Paper's purpose and objectives; (2) correlations between flow and survival; (3) flow management conclusions; (4) the need to better evaluate and describe White Paper conclusions in the context of hydrologic conditions in the Snake River system; (5) the need to fully state assumptions inherent in the White Paper conclusions; and (6) several miscellaneous topics. These comments are intended as a constructive contribution to the salmon recovery discussion.

B.) White Paper Purpose and Objectives

The purpose of the White Paper was "to provide a synthesis of scientific information regarding the effects of river flow through the hydropower system, as it is presently configured and operated, on anadromous salmonids." However, the White Paper appears to be a primary support document for NMFS' "Biological Opinion for Operation of the Federal Columbia River Power System including the Juvenile Fish Transportation Program and the Bureau of Reclamation's 31 Projects, including the Entire Columbia Basin Project" (referred to hereafter as the Biological Opinion). As such, the White Paper is used not only as a synthesis of current scientific information, but also serves as a basis for recommendations contained in the Biological Opinion. Given this role, the White Paper should have included more detailed analyses of the potential impacts and benefits of recommendations made in the Biological Opinion on the basis of the White Paper.

C.) Correlations between Flow and Survival

The White Paper presents a series of correlations between survival and flow, temperature, and turbidity. However, the correlations using hatchery-raised, subyearling fall chinook do not imply a cause and effect relationship between flow and survival of subyearlings (which NMFS recognizes), and therefore should not be used as a basis to justify flow augmentation. This is primarily because the experimental design leading to these data did not address other factors that appear to influence migration characteristics and survival.

Concerns about conclusions being drawn from the flow and survival correlations are addressed in Dreher et al. (2000), which was included in Idaho's Biologic Opinion comments (Part I, Exhibit 4, submitted September 29, 2000). First, although there is an apparent correlation between flow and survival, there is a stronger correlation between estimated survival and release date. NMFS' experimental design assumed that sequential releases of hatchery-raised fall chinook would not influence survival independent of flow, temperature, and turbidity. The high correlation between time of release and survival makes this assumption questionable.

Second, median travel times for hatchery-raised, subyearling fall chinook did not generally correspond with flow rates. For instance, travel times for the early percentile surviving fish (5th, 10th, and 25th percentiles) were less at lower flows than at higher flows for most releases. Median travel time for the 5th percentile surviving fish decreased from 33 days to 16 days between the 1st and 6th weekly releases, despite a decrease in the 5th percentile flow indices during the same time from 122 thousand cubic feet per second (kcfs) to 63 kcfs. These travel times and arrival patterns were contrary to what would be expected if the higher flows (i.e., greater water velocities) resulted in significant improvements in survival.

The fact that travel times are inconsistent with flow rates may result from (1) the migration rate being weakly dependent on velocity in the flow ranges considered or (2) other important non-flow factors influencing the migration rate. An example of a non-flow, physiological factor is "readiness to migrate." The NMFS study used hatchery-raised, subyearling fall chinook as surrogates for wild fish. Implicit in the use of these hatchery-raised subyearlings in sequential weekly releases is that the fish were equally "ready to migrate" when released. Longer travel times for portions of early-released subyearlings, and faster travel times for portions of later-released subyearlings, despite substantially decreasing flows, suggest that the fish in the weekly sequential releases may not have been equally "ready to migrate." Differences in states of "readiness to migrate" would confound the analysis of flow and survival relationships. Correlations of flow and temperature with travel time and survival are only meaningful if the groups of fish studied are actively migrating or relatively similar in their physiological state of "readiness to migrate. "

Third, the White Paper shows that flow rates, velocity, temperature, and turbidity are correlated, or inversely correlated, with one another. The current data are insufficient to allow delineation of the effects of individual attributes of flow. Understanding the effects of individual attributes of flow, particularly the usefulness of flow augmentation to compensate for the effects of reservoir impoundment on these attributes, is fundamental to determining the effectiveness of flow augmentation efforts for increasing survival of subyearling fall chinook salmon.

Fourth, additional problems with existing studies must be addressed prior to making conclusions about the efficacy of flow augmentation. These include use of flow and temperature indices that may not represent overall migration conditions; release timing of hatchery-raised fish that is not representative of natural migration; relatively high post-release mortality; and the inability of reach survival estimates to reflect the full spectrum of potential effects from altered water velocities, temperatures, and turbidity during migration (e.g., altered migration timing, bioenergetics, and transition into the estuary and ocean).

We do not suggest that flow, or the attributes of flow (water velocity, temperature, and turbidity) are unimportant to the migration and survival of subyearling fall chinook salmon. However, existing correlations between survival of hatchery-raised, subyearling fall chinook salmon with flow rates and water temperatures do not support the postulation that augmenting mainstem Snake River flows improves subyearling survival.

D.) Flow Management

Flow management goals in the Biological Opinion seem to be based on conclusions summarized in the White Paper. Again, we question the strength of these conclusions.

For example, the White Paper states that (pg. 56):

> Evidence for a survival benefit to fall chinook salmon from flow management is supported by research results. Data sets consistently demonstrated strong relationships between flow and survival, and temperature and survival.

The PIT tag studies reviewed for the White Paper, to our knowledge, were not used to separate the effects of flow management on survival from the effects of total channel flows. In other words, the PIT tag studies did not test survival benefits from flow management – the studies were not used to separate the specific effects of flow augmentation during the 1995-1998 period from the effects of non-augmentation flows. To our knowledge no studies have focused on the specific effects of flow augmentation. It therefore seems inappropriate to state that "Evidence for a survival benefit to fall chinook salmon from flow management is supported by research results" because the specific effects of flow management, including flow augmentation, have not been evaluated.

The White Paper acknowledges that the benefits of flow augmentation are difficult and somewhat speculative to quantify (pg. 56):

> Flow management for the Snake and Columbia Rivers appear to provide salmon survival benefits. However, the benefits are difficult and somewhat speculative to quantify and are not easily demonstrated for every population at all times.

Despite the difficulty of quantifying benefits of flow augmentation, the correlations between flow and survival (which do not necessarily imply cause and effect) are being used to call for continuing flow augmentation in the Biological Opinion. Again, the White Paper has not, in our opinion, adequately shown that augmenting mainstem Snake River flows improves subyearling survival.

E.) Hydrology of the Upper Snake River System

A detailed discussion of the hydrology of the Upper Snake River System would be extremely helpful to the analyses summarized in the White Paper. We recognize that the focus of the White Paper is the reaction of salmonid populations to variable environmental conditions. However, the hydrologic constraints of the Upper Snake River Basin are critical to evaluating the potential impacts of recommendations made in the Biological Opinion regarding Snake River populations, which are based, in part, on conclusions presented in the White Paper.

For example, NMFS recognizes the risks inherent to using water from the upper Snake River Basin to augment flow in the Lower Snake River (pg. 57):

> The ability to substantially increase flow augmentation in the Snake River to benefit these fish is limited and the use of potential sources of water to augment flows in the late summer poses risks as higher water temperature is a concern. However, downstream summer migrants continue to suffer high mortality. Thus, with existing project configuration and outmigration timing, additional flow augmentation to benefit Snake River fall chinook salmon would likely increase survival.

These sentences underscore the importance of understanding *which* components of flow affect migration and survival, and *how* the flow components influence, or could influence, migration and survival. Furthermore, it is important to understand and predict the effects of changes in flow management within the context of current and potential hydrologic conditions in the mainstem Snake and the upper Snake River Basin.

It also is unclear from the above quote *which* downstream summer migrants are suffering high mortality. Data are not given for native fish, so we assume that the statement refers to hatchery-raised fish. If the statement does refer to hatchery-raised fish, is the high mortality caused by river conditions or by release timing? Will the higher late season mortality, possibly caused by release timing (Dreher et al., 2000), be reduced by the additional flow from the upper Snake River? The answer to this question is important and, in our opinion, has not been adequately addressed in the White Paper.

F.) Assumptions

The White Paper should include a list and discussion of the impacts of all of the assumptions inherent in the conclusions summarized in the White Paper. Review of the assumptions can be used to help interpret the strength of conclusions made. For example, the correlations between flow and survival using hatchery-raised fall chinook salmon presented in the White Paper are built on the assumption that sequential releases of hatchery-raised fall chinook (reared from the same stock) would not influence survival independent of flow, temperature, and turbidity. The high correlation between time of release and survival makes this assumption questionable. Assumptions such as these should be included in the scientific synthesis contained in the White Paper.

G.) Miscellaneous Comments

Pg. 5: "*In the present hydropower system, the mainstream reservoirs are maintained at a relatively constant elevation, regardless of discharge, and water velocity varies more directly with flow than it did prior to dam development.*" This may be true, but water velocities are lower by approximately an order of magnitude at all flows in comparison to pre-dam conditions.

Pg. 5.: *If the augmentation water is cooler than the receiving water, water temperature of the receiving water is decreased through the mixing zone …"* Significant temperature stratification may occur in the Lower Snake River, reducing the mixing that otherwise might be expected.

Pg. 7: "*Flow and water temperature can affect migrating juvenile salmonids in many ways. Flow influences travel time …*" This is not clear, especially for fall chinook (for which flows currently are being augmented); median travel time rates for hatchery-raised, subyearling fall chinook are relatively constant compared to flow (Dreher et al., 2000). For spring migrants, the "*effect of river velocity on migration rate … is not static and likely has a seasonally-varying component*" (pg. 10). Furthermore, "*relationships between flow and survival and between travel time and survival for yearling migrants though impounded sections of the lower Snake river were neither strong (within or between years) nor consistent from year to year*" (pg. 17).

Pg. 23: "*A strong relationship exists between median passage date at lower Granite versus mean temperature in the Snake River (Fig. 8), indicating that processes regulating maturation through the smolt phase are under temperature control*." This seems to be an overly strong statement, given that the correlation in Figure 8 is based on seven data points. Again, such a correlation does not necessarily imply cause and effect.

Pg. 25: The 5th passage percentile was used for a basis for calculating flow and temperature indices. However, the hatchery-raised subyearling fish may not begin migration immediately after release (as indicated by 5th percentile travel times that were almost twice as long at higher flows than at lower flows), in which case the 5th percentile flow indices would not represent an accurate indication of flow conditions during migration (see Dreher et al., 2000).

H.) Summary

The White Paper represents a substantial effort of synthesizing scientific information with regard to the effects of river flow on anadromous salmonids – a contribution to the current discussion of salmon recovery. However, we believe that the White Paper (1) should have an expanded scope to fulfill its role as a basis for the Biological Opinion; (2) should not rely on current PIT tag data using hatchery-raised, subyearling fall chinook salmon as a basis for recommending additional flow augmentation; (3) should better evaluate and describe hydrologic conditions in the Snake River system; and (4) should fully state and discuss assumptions inherent to the conclusions reached in the White Paper.

I.) References

Dreher, K., C. Petrich, K. Neely, E. Bowles, and A. Byrne. 2000. Review of Survival, Flow, Temperature, and Migration Data for Hatchery-Raised, Subyearling Fall Chinook Salmon above Lower Granite Dam, 1995-1998. Available from the Idaho Department of Water Resources, 1301 North Orchard Street, Boise, Idaho 83706.